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COLLEGE-LEVEL INSTRUCTION: DERIVED RELATIONS AND PROGRAMMED INSTRUCTION

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Recent research has demonstrated the effectiveness of programmed instruction that integrates derived relations to teach college-level academic material. This method has been demonstrated to be effective and economical in the teaching of complex mathematics and biology concepts. Although this approach may have potential applications with other domains of college learning, more studies are needed to evaluate important technological variables. Studies that employ programmed instruction are discussed in relation to future directions for research.

Key words: college students, derived relations, programmed instruction

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Recent advances in college-level instruction have included programming for derived relations. A derived relation is an outcome that results from directly teaching the interconnectedness of stimuli. The most important type of derived relation involves relating two or more stimuli that have never been directly paired but share an association with a common stimulus (Critchfield & Fienup, 2008). Programming for derived relations is accomplished by organizing stimuli according to classes and types of stimuli (e.g., see Figure 1 of Fields et al., 2009) and determining what is likely to emerge, given the relations directly taught. For example, when teaching about different classes in biology, classes might consist of *mammal* and *reptile*, and stimulus types might consist of class name (i.e., *mammal* and *reptile*), skin type (i.e., *furry* and *scaly*), birth method (i.e., *live* and *egg*), and thermophysiology (i.e., *warm-blooded* and *cold-blooded*). Direct teaching of class names with each stimulus type would likely result in the emergence of relations between the stimuli without directly teaching those relations. These applications are economical in that individuals demonstrate adaptive behavior in excess of that which was directly taught (Fienup & Critchfield, 2010; Stromer, MacKay, & Stoddard, 1992; Toussaint & Tiger, 2010).

Both relational frame theory (RFT, Hayes, Barnes-Holmes, & Roche, 2001; Ninness et al., 2009) and stimulus equivalence (Fields et al., 2009) paradigms have accounted for derived relations. From an application standpoint, both paradigms are inherently interested in classes of physically different stimuli that are functionally related. Instructional applications from both

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paradigms involve teaching the minimal number of relations between members of a class so that all relations between stimuli emerge in an efficient manner.

College-Level Instructional Research on Derived Relations

Typically, derived relations research has involved instruction on how various representations of stimuli are positively related. The majority of these applications have focused on statistical and mathematical concepts. For example, Ninness et al. (2006, 2009) programmed for derived relations when teaching college students trigonometry and algebraic concepts. The instructional package included verbal rules and match-to-sample training. The stimuli involved standard equations ($y = 6 - \sqrt{-x-4}$), factored equations ($y = \sqrt{-[x+4]} + 6$), and graphical representations. First, students were taught rules about how the stimuli were related. Next, students received computerized match-to-sample training of the respective stimuli. Following instruction, students consistently demonstrated novel forms of behavior, or derived relations, such as matching graphs with standard equations. In addition, they generalized responding to novel types of functions. Recently, Ninness et al. (2009) incorporated the construction of graphs. This approach allowed students to complete complex reciprocal trigonometric relations.

Fields et al. (2009) taught college students concepts of statistical interactions. Students were taught four unique categories of interactions (no interaction, divergent, synergistic, crossover) and four different representations of the category (graph, a description of the interaction represented in the graph, name of interaction, and definition of interaction). Using only match-to-sample training, the experimenter taught the students three relations. Following teaching, students generalized responding to novel stimulus relations, including matching graphs and definitions. Instruction involving 12 relations (three relations by four classes) resulted in a total of 48 relations (i.e., four times as many relations learned as taught). The authors also found that students were able to generalize responding to novel graphs.

Additional examples were provided by Fienup and Critchfield (2010) and Critchfield and Fienup (2010) in teaching concepts of inferential statistics and hypothesis decision making. In the first lesson, students were taught two statistical categories: one that involved statistically significant stimuli and one that involve statistically nonsignificant stimuli. Next, students were taught to match hypothesis- and results-based statements to statements about the null hypothesis (reject or fail to reject) and scientific hypothesis (consistent or inconsistent). Last, students were taught to incorporate statistical information with hypotheses and results to make accurate decisions about hypotheses. In total, students were directly taught 40 relations and demonstrated up to 144 relations (i.e., 4.7 times as many relations learned as taught). In addition to these demonstrations of the application of stimulus equivalence to math instruction, similar applications have also been demonstrated with brain–behavior concepts (e.g., Fienup, Covey, & Critchfield, 2010) and disability categorization (Walker, Rehfeldt, & Ninness, 2010).

Future Directions

Several areas are in need of future research. For example, a number of new content areas could benefit from instruction that programs for derived relations. Areas such as geography, the taxonomy of biological organisms, psychiatric disorder categorization, and language all involve multiple representations of conceptually related stimuli. Some of these areas have already been investigated with young learners (e.g., geography, LeBlanc, Miguel, Cummings, Goldsmith, & Carr, 2003; foreign language, Joyce & Joyce, 1993) and could be extended to include more complex topics that are taught in college curricula.

A significant practical challenge involves the technology for promoting derived relations. Other areas within applied behavior analysis have agreed-upon technology (e.g., functional analysis, Hanley, Iwata, & McCord, 2003), but there is no consensus in the literature on what experiences a college student requires to derive relations reliably. The lack of consensus on how to program for derived relations can be a deterrent to new experimenters and instructors who want to program for derived relations. Areas of divergence in the literature include the sequence of teaching, the sequence of testing and training, the content of testing, the mastery criterion, and the type and frequency of feedback.

This issue can be illustrated by comparing and contrasting research. Ninness et al. (2006) combined match-to-sample training with verbal rules about how the stimuli were related, whereas Fields et al. (2009) used match-to-sample training alone. Both used linear-series training (e.g., A→B, B→C), but Ninness et al. preceded and followed this training with mixed tests of all relations. Fields et al., on the other hand, interspersed additional tests before, during, and after training to measure the gradual emergence of derived relations.

The field has no agreed-upon approach for even seemingly simple parameters such as type and frequency of feedback. Fields et al. (2009) provided visual corrective feedback on each trial and then faded feedback across trials. These authors evaluated mastery based on blocks of trials, meaning that after the passage of a set number of trials, the computer program evaluated whether a criterion had been met since the last evaluation. More recently, Fienup et al. (2010) incorporated a rolling mastery criterion. Participants were required to respond correctly on a certain number of consecutive trials. These authors also provided auditory feedback and visual feedback that allowed participants to view how many trials were on a test or how many consecutive trials on which they had responded correctly.

It is important to determine which of these inputs are necessary and sufficient when designing efficient instruction. It is not enough to claim an instructional package is efficient by illustrating that the stimulus relations output exceeds the input. The actual teaching portions of these computerized programs are likely efficient. What has been given less attention is the intensive nature of the testing batteries. Measuring the emergence of derived relations is typically done across many trials (e.g., Fienup et al., 2010, involved a minimum of 448 test trials). Programmed instruction is a package, and research is needed to determine how to measure the emergence of derived relations accurately while maintaining an efficient program of instruction.

College-level instruction that programs for derived relations has shown promise for future applications. This type of instruction, whether using an RFT or stimulus equivalence paradigm, can be applied to a variety of academic contents. However, more research is needed to refine the technology of programming for derived relations in instructional settings, especially if the goal is wider acceptance, use, and application of derived relations.

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